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SATELLITE IMAGERY AND CARTOGRAPHY

G. FORGIARINI G. LAMARQUE

Range maps

This set at a scale of 1: 500,000 is the logical extension of earlier volumes produced on the West African Sahel between the rainfall isohyets of **150 mm** and **600 mm.** The **12** sheets in this atlas of the Sudan are complementary to the **34** already published. It is now possible for scientists, planners and developers to consult a set of **46** maps on the range production potentia of the whole of the traditional livestock production zone, covering more than **2,100,000 km^2** extending from the Atlantic Ocean in the west to the Sudanese-Ethiopian frontier in the east.

Scale

Earlier thematic maps have been of a very general type, varying in the quality of the information they provided, often not covering complete areas, and of varying scales. It is possible to prepare an uniform comparative presentation only if data are treated equally and are in the same detail for the whole of a particular study.

It was apparent at the outset that mapping the agropastoral zone of the Sudan would require the use of LANDSAT imagery, for several reasons, but principally because of the vast area - **600,000 km^2** - to be covered and the lack of an existing set of detailed and up-to-date maps. The scale adopted required enlargement of the false-colour LANDSAT images to a scale of 1: 500 000. This projection is sufficiently close to the basic mapping scale that has been adopted and allows of adequate interpretation and transfer of information. A series of ground-truth exercises showed that such interpretation and transfer was indeed generally correct.

METHODOLOGY

Conception of the maps

The Sudan, as long ago as 1973, was among the pioneering African countries in the use of first-generation satellite imagery. Some of the results of that early work have been published (and been made use of in the present work, while others have unfortunately not yet seen the light of day. A total of 42 satellite images was used for the maps, of which 32 were in false colour and 10 in black and white, these last being used in order to obtain data for a very narrow band of country to the south of the project area (see make up table for details).

In spite if the large number of LANDSAT images available for the region the choice of the ones actually used was limited by the absence of cloud cover and the need for them to fall within a certain time spans. Most of the images thus date from the dry season of 1986. This selection has not caused any problems for the inventory that has been done, which includes land use, topography, soil type, geomorphology and vegetation as the principal criteria. These parameters are relatively stable but can be adapted to take account of any new developments.

Interpretation of the satellite images

The scale of enlargement was sufficent to allow a relatively accurate interpretation of the boundaries between the various unit. It needs to be stated, however, that some detail is always lost when using satellite imagery as the smallest area that can be identified is always of about 0.42 ha (1 acre, 1 feddan) whatever scale of enlargement is used.

The mapped units did not require major changes when they were transferred to the topographic maps but some formations were occasionally amalgamated for thematic reasons.

The initial interpretation work comprised the identification and the stratification of the major ecological units by tracing them on the map. The main reason for this operation is to reduce the internal variability of the units and to obtain an immediate and high level of uniformity.

The regional inventory thus consists of:

Major natural regions;

. **mountains and inselbergs**, the volcanic areas of Darfur and the hilly areas along the Ethiopian frontier, weathered and eroded glacis, sandy plateaux, and dune systems classified by alignment and morphology;

. **gently undulating "qoz"**, clay plains, waterlogged depressions, and permanent and temporary standing water;

. **the major river systems**, including thalwegs, valleys, alluvial terraces and flood plains classed in relation to the origin of the deposited material (sand, clay, loam or volcanic ash);

Regions affected by anthropogenic activity;

. **irrigated, mechanized** and **traditional** rainfed agriculture;

. **urban areas**, roads and lines-of-rail, where these could be identified.

The second operation was designed to establish the relationship between the identified major units and their vegetation. Individual plant species will thus be found on various type of soil, in different geomorphological areas and under several climatic regimes.

Other clearly visible features were used for further subdivision of the major units. These included, in particular, dynamic elements such as signs of degradation through weathering or by overgrazing. The vegetation gradient from north to south, and the effects of orography and aspect, particularly for the Darfur jebels, also assisted in deciding on the subdivision.

Maquettes and final versions

Twelve maquettes at the scale of the LANDSAT imagery were finally prepared. These draft maps were checked by the cartographers by the use of hand-colouring, this providing the most effective visual method of the accuracy of the work carried out. Modern cartographic methods were not used until the final stages of the mapping.

Following technical verification, the maquettes were transferred, without any problems, to the American **ONC** topographic base maps. The Lambert-Mercator conical projection with fixed longitudes used for these maps is compatible with those of the French National Geographical

Institute which was used for the West African Sahel countries. The earlier maps prepared for the Chad-Sudan border area thus match very well with the present ones.

The final phase of map preparation used the latest available technology. The maps were printed in four colours using the BARCO automated system. The legend was first completed and used as the data base to instruct the software as to the exact nature of each of the 80 formations identified from LANDSAT imagery and used on the maps. Special maquettes were then constructed which carried the designations of the mapping units (DR1, DR2, etc.) and the boundaries of the units which had already been scanned by the system. The colour separations were then produced in black, cyan, magenta and yellow.

Toponymy

The toponymy was established from the standard British maps that are still most used in the Sudan and which are indeed the only maps available at various scales from 1: 500,000 to 1: 250,000. The spelling of places and other names used on these maps has largely been retained for the present ones, although there are some minor modifications resulting from recent Sudanese work and from presentations at international fora.

Map legend

The legend is presented in tabular form to include, from left to right, the mapping units described on the basis of their geomorphology and then the typical woody vegetation and field layer of these units. This basic data is complemented by notes relative to land use and other factors and occasionally by some of the constraints attached to each unit.

Water resources

Boreholes and wells have been marked on the range maps because these are a major contributor to the pastoral value of an area. Each conventional sign is accompanied by information - provided by the Sudan office of BRGM - on the depth of the bore or well, static water level, salt content, and discharge.

Conclusion

In addition to making this atlas available to a wide variety of potential users, a whole data base of information essential to a full understanding of Sudanese livestock production has been established. This data base is now available for future up-dating. For example, the state of the pastures can be regularly monitored and the latest changes recorded, on computer diskette. The end result is, in fact, an essential basic tool in the development of a **Geographical Information System** on livestock production in the Sahel zone of the Sudan.

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IMAGERY AND MAPS

0 4 8 12 16 20 km

179 - 49
(15 - 9 - 86) LANDSAT 4 - 5 imagery

192 - 52
(6 - 1 - 72) LANDSAT 2 - 3 imagery

KUTUM
MALHA
SODIRI
KHARTOUM
KASSALA
ED DAMER
ATBARA
NYALA
EL FASHER
EL OBEID
KOSTI
GALLABAT
CHAD
ETHIOPIA

179 - 49 (15 - 9 - 86)
178 - 49 (5 - 11 - 84)
177 - 49 (5 - 2 - 86)
176 - 49 (29 - 9 - 87)
175 - 49 (8 - 10 - 87)
174 - 49 (31 - 1 - 86)
173 - 49 (10 -10 - 87)
172 - 49 (19 -12 - 86)
171 - 49 (10 -11 - 86)
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171 - 51 (10 -11- 86)
192 - 52 (6 - 1 - 73)
191 - 52 (23 - 1 - 73)
190 - 52 (17 - 12 - 72)
189 - 52 (16 - 3 - 73)
188 - 52 (9 - 11 - 72)
187 - 52 (19 - 1 - 73)
186 - 52 (7 -12 - 85)
185 - 52 (4 -12 - 73)
184 - 52 (5 -11 - 72)

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